CONTINUOUS VOLUMETRIC METERING OF CONCRETE INGREDIENTS
THE ARAN EQUIPMENT APPROACH TO ACCURACY - HOW AND WHY IT WORKS

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Overview

Early use of Portland Cement to make concrete was most often based on volumetric proportioning of the various ingredients. Commonly the required number of shovel loads of aggregate, sand and cement were placed in a mixing device with water added until the desired slump or workability of the concrete was reached. Unfortunately, the shovel is not a very precise volumetric measuring tool and proportioning by that means produces a high degree of variability. This method of proportioning was essentially a batch approach. In the intervening years concrete ingredients have been weighed on a batch basis rather than dispensed as a discreet volumetric measure for a specific quantity of completed mix. Batch weighing therefore has become the almost universal means of proportioning concrete materials.

For applications where large throughputs are required, a batching system tends to run into a number of conflicting constraints and requirements. One solution to increasing the throughput of material in unit time is to increase the size of the batch proportioned and mixed. Increased batch sizes require increased cycle times in respect of ingredient weigh-up, material charging to the mixer, mixing time and discharge time. There comes a stage when these constraints offset each other to the point where throughput plateaus, and duplication becomes necessary. An obvious solution to this dilemma is to move to a continuous metering and mixing process.

Continuous mixing systems have been applied with varying degrees of effectiveness for the preparation of soil-cement, hot mix asphaltic concrete, roller compacted concrete and even conventional slump concrete. Various combinations of volumetric and continuous weighing methods have been used in each of these applications.

The biggest limitation of volumetric metering systems to date has been the poor degree of consistency and repeatability which many earlier inadequately designed metering devices were able to offer. Less than totally desirable mix uniformity provided by these older systems has led to a popular misconception that volumetric metering is by nature non-uniform and inaccurate and should be relegated therefore to less critical mixes such as soil-cement for subgrades and other similar applications. A recent statement in a construction magazine viewing the State of the Art of Roller Compacted Concrete particularly in North America made the following statement:

> "Such equipment batches coarse aggregate accurately, sand fairly accurately, and cement (or flyash) relatively inaccurately."

ARAN Equipment Pty Ltd from Brisbane, Australia has developed a range of State of the Art machines for the proportioning and preparation of cemented materials from basic soil-cements through cement treated base, roller compacted concrete to high quality conventional slump concrete. These systems have been developed in both mobile and static form using both batch weighing and alternatively continuous volumetric methods to proportion the ingredients. A commitment to innovative technology development has produced continuously metered volumetric plants which offer consistency, uniformity, and accuracy standards equal to and better than their comparable manual or automatic equivalents using batch weighing methods. Whilst volumetric metering systems have a number of identifiable limitations, likewise batch weighing systems have a similar number of different limitations. This discussion considers the factors which are important to the proper proportioning of concrete materials as well as those factors which in reality are relevant to the uniformity and definition of the mix ultimately produced.

Weight, Density, Shape or Volume - Which Matters Most?

Materials such as roller compacted concrete, cement treated base and to a slightly lesser degree conventional slump concrete are dense graded products. Effectively, it is necessary for the voids left between larger irregular shaped stones to be progressively filled by smaller particles. It is clear therefore in terms of the final composition of a blended and consolidated material matrix, that the volume and shape inter-relationships of those particles are the key determinant factors in how effectively proportions of various sized particles work together to achieve that objective. A change in the shape of particles from round, such as is experienced in many river gravels, to fully crushed or even very elongated particles will markedly alter the proportions of each size required to accomplish a consolidated dense grading. Such a shape change will of course also affect the bulk density of the individual graded stone when treated as a separately sized component.

In the final analysis therefore, it is the interaction of volume and shape which is important. Using the weight of various aggregate components as the determinant factor as to how much of each ingredient is added to a particular mix, is merely an alternative, and often more convenient, method of dealing with the problem which in the end is not primarily weight related.

In the establishment of a mix design, it is normal to prepare a number of trial mixes and to adjust the proportions of each component until the desired result is achieved. Adjustments of the weight proportions particularly of the aggregate components, often reflect the differences in shape and stone density from one mix to another, using different source materials. In effect what is happening is that an essentially volume relationship is being brought back through a trial mix to a weight relationship. Weight, volume and shape therefore are interactive. The process of relating them through trial mixes can be accomplished in either direction. Provided the degree of consolidation of a particular particle size component is maintained relatively uniformly during metering, there is therefore little valid argument to establish an end result priority of weight or volume in relation to the other. If the absolute criterion of measurement is weight, then obviously weight has a superiority. If the absolute criterion of measurement is the interaction of particles in what effectively becomes a volume grading in the final analysis, then weight is merely a step in achieving that, and has less absolute significance in itself.

It is clear therefore if weight is used it has to be derived from a densification interaction of size and shape and proportions of different sizes and shapes. If volume is used it has to be related at a consistent level of consolidation during metering of the individual single sized components. Variations in quality control of the incoming aggregate in such areas as stone types with varying densities and differing shape characteristics, (depending often on whether the crusher was running choked or partly fed at the time of crushing), will produce variances in the actual final product if either approach is adopted.

It has been common practice in the hot mix asphaltic concrete industry to use continuous belt weighers for the metering of aggregate and sand components. Trials conducted by asphaltic concrete mixing operators in Australia have indicated that where weighing is removed from a system and straight volumetric metering of coarser aggregates in particular is used, the actual grading control of the end product often improves. Continuous weighing metering systems such as those used in the asphaltic concrete application tend to use a feeder weigh platform to monitor the unit mass of material passing over a particular roller. This is usually used as a trim signal to adjust the speed of the feeder, either by increasing it in response to a low mass signal, or by reducing it in response to a high mass signal.

These feeders are invariably set up with a uniform strike-off depth of feed, which is in effect, metering loose material. This means that if the feed is kept absolutely constant, the displaced volume is also absolutely constant. If the mass falls off, the reason is not necessarily a lack of sufficient stones of the right size to perform the end product role requirement. It can be a change in the type of rock which is being used at that particular time, with resultant different density, or alternatively and more often a change in the particle shape of the stone or its moisture content. Increasing or decreasing the feeder speed in response to such changes is not necessarily solving the real problem at hand. It is rather increasing or decreasing the number of stones of the size delivered through that feeder in a manner not necessarily related to its end function. It is therefore arguably more meaningful to meter such materials on a strictly accurate volumetric basis with attention being paid to consolidation at the feed point.

If weigh platforms are used, it is more meaningful to use them as a reference check on the characteristics of the aggregate passing for the purpose of quality or moisture control rather than as a trimming signal to provide more or less of that aggregate size by speeding or slowing the feeder. Unfortunately, many systems exist in which little attention is paid in plant design, to the manner in which materials enter the feed zone, their flow characteristics, or their consolidation. These problems have been addressed in ARAN Equipment developed plants to the extent that volumetric metering of all ingredients on suitably equipped plants translates back to either weight or volume to a degree of accuracy which matches or surpasses comparable batching procedures, whether the manual or automatic.

The Significance of Water in Metering or Weighing

All that is of consequence as far as the spatial relationships of the particles in the end dense graded product is concerned, is the number of such particles in proportion to those of other sizes and their particular size and shape. Retained moisture therefore is a problem which potentially can confuse the issue endlessly. This is particularly so with sands.

At the outset it is fair to say that there is no absolutely perfect solution to this problem. It is important therefore to analyse the various approaches which have been, and can be used, as to how logical and appropriate they are to the end product of the process.

In the case of batch weighing it is usually recognised that moisture adds to the total weight of a required number of particles of a particular size and that the compensation must be made by deducting that from the target mass for the moisture level present. This has sometimes been done by taking assessments of moisture levels in stockpiles or by various moisture measuring devices such as resistance probes, capacitance probes and even infra red systems. None of these systems behave with absolute accuracy. The better systems are generally quoted as having accuracy of within plus or minus 1%, or 2%, subject to a number of other factors remaining uniform. For example, the electrical characteristics of the stone itself, its dialectric strength or its relflectivy can each affect the measured moisture content in different systems. Since these other factors do not remain constant there is obviously a degree more variability resulting from those factors.

To be meaningful in a batching situation, this moisture level must be measured and computed during the feed of each individual batch, (particularly sand), to the weighing hopper. Its significance must be calculated by the process controller and target weight adjusted and corrected during the weigh-up cycle itself. High speed processors can generally handle such a role with some degree of competence, however moisture content also has a significant effect on the flow characteristics of materials, particularly sands, and further problems are encountered in assessing and correcting inflight materials between the closing of the discharge gate and the registering of the weight in the weigh hopper. This technology has reached a relatively high level of sophistication in some batching type plants and a reasonable control of weight correction for moisture content is able to be achieved.

In the case of continuous metering systems however, the effect of moisture on weigh controls is very different. Measurement of moisture content on a continuous basis can be achieved, however this accuracy is obtained only at considerable expense. The meaning of such measurements are, in logical analysis, of doubtful value. The procedure of weighing material passing over a feeder belt and using that signal for feeder speed correction is at its most illogical in many hot mix asphaltic concrete plant applications.

It is not unusual for these systems to have factors in their control systems which call for the entry of a moisture content. This is often done by assessing the stockpile moisture content of the sand and entering a factor, say 10% into the controller. The moisture content of sand from a stockpile, particularly if rain has been occurring, is generally not all that uniform and the controller happily adjusts the rate at which the required number of particles of sand are dispensed in response to their moisture content, thus fluctuating what in effect would be the dry weight. The resultant metered material is then fed into a drier, and the moisture so carefully measured is evaporated off. What remains is the dry weight of sand material, or alternately a certain number of particles of a particular size per unit time. There is therefore no great significance in having weighed the water which is to be evaporated off in the first place, or to have used it as a dry weight trimming signal.

In concrete applications, the water remains, and its presence must be compensated for in the addition of the extra water, rather than in the addition of the dry weight of sand, (or the number of particles of a particular size per unit time). In assessing the relevance of a strictly volumetric metering approach for sand, the bulking characteristics of wet sands whereby these materials can change their volume significantly when wet is the major question to be addressed.

This bulking effect can logically be divided into two distinctively different regimes. If consolidated and compacted, dry sand is wet to the level of saturation, some bulking does occur due to the presence of water and its surface tension relationships in the interstices of the matrix. This is of relatively minor consequence and is of less significance than the variation caused in a batch weighing process by water, with respect to the required number of particles of a particular size in a particular batch.

The second factor in the bulking of sands is the spacing out of particles or the introduction of air, particularly during handling of wet sand. This can cause very substantial variations in the bulk dry density of wet sand. (Moisture being considered separately.) Sand or other fines are important in the establishment of a dense graded mix. Most earlier volumetric metering systems have simply struck off sand and have not attempted to address this problem. It can be addressed in a number of ways. One is to accurately measure the moisture content using a device such as an infrared back scatter moisture meter, and to compare the measured moisture with the theoretical required dry weight of sand passing over a weigh roller, and to process the signals through a complicated mathematical control programme to correct the feed depth or the feed speed for the present moisture and the loss of density (caused by aeration) due to handling bulking.

An alternative approach which has been developed and applied by ARAN Equipment Pty Ltd and is the subject of patent applications, is to recompact the fine components at the point of volumetric metering to remove to the greatest degree practicable, voids induced by the handling of moist fine materials. If properly set up and adjusted, these ARAN density classification feeders reduce the volumetric error almost to that caused by the moisture effect only. It can be seen therefore, that if this procedure is adopted, that which is passed from the feeder is as close as realistically achievable to the required number of correctly sized particles per unit time, required to match that of other sized particles. Bulking correction is not normally necessary on aggregates of greater size than 5mm or 3/16 inch. If handled properly therefore, it is not necessary, nor logically desirable, to weigh such feeds on a continuous basis with respect of the dry weight, (or the number of correctly sized particles per unit time). In fact such a procedure is often counterproductive.

<u>Security and Accuracy of Volumetric Aggregate and Sand Feed</u>

In suitably equipped ARAN Equipment continuous mixing plants the security and uniformity of feed is guaranteed by a number of factors. Feed hoppers are designed with steep angles appropriate to the types of materials for which the plants are designed. Feed bins which form part of plants handling separately metered materials having difficult flow characteristics, have a special design with modified Valley angles. The presence of the required depth of material on the feeder is monitored by a sensing device which provides an alarm in the event of nonavailability of the correct amount of material at any time.

Automatically controlled plants have low level sensors to ensure that sufficient head of material is always in the feed hopper to provide the uniform feed to the metering feeder. This establishes relatively assured uniformity of density, particularly in coarser components. The fact that the material is drawn from a feed hopper and turns from a vertical to a horizontal path, tends from observation and analysis to stabilise the density coming into the feed throat area. (This does not apply to the same degree to wet sands.) Where separate multi compartment proportioning and blending system plants are used in ARAN Systems, particular attention is paid to the preblending of those materials as they enter into the blended aggregate surge feed and metering hopper. Numerous field quality control tests confirm that the degree of proportioning accuracy can be achieved by ARAN feed systems is maintained on both micro and macro sample levels.

<u>The Metering of Cement and Flyash, Lime and Other Fine Particulate Materials</u>

A key element in the perceived poor performance of continuous mixing plants for the preparation of cemented materials has been the inadequacy of most prior metering systems for fine particulate materials such as cement and flyash. In some instances, screw feeders have been applied to the metering of cement. The results obtained for this type of metering device have been inaccurate in the extreme and logical analysis of the manner of function of such a device explains why this is the case.

In a screw feeder it can be postulated that the material moves linearly along the case with no rotational movement with respect to the case, but only in shear with the rotating screw blades. If this argument were the case then the displacement of the feeder would be the displacement of the screw. Alternatively it could be argued that all motion was relative to the case and that the material rotated with the screw element as a rotating plug of material, (such as if the feed material had all gone solid). Since feed normally comes out of the other end of such a feeder, this is clearly not the case, but nor is it the case that the displacement of the feeder is the displacement of the screw. In fact the true relationship is at some indeterminant point in between and it varies with the type of material, differential speeds, the pitch of the screw, the relative polish of the screw and the case, and many other factors. Whilst a screw will act as a conveyor it has absolutely no capability to act as a metering feeder and wild variations will occur if such an attempt is made.

The heart of most earlier systems for the continuous metering of cement in pavement mixing has been the rotary vane feeder. This device was originally developed as an air lock between a silo or vessel containing a particulate material and pneumatic conveying system or other section of a process where differential pressures exists between the vessel and that part of the process. If the advertising and rating literature published by manufacturers of rotary vane feeders for the process industries is studied, a significant observation that emerges is the fact that these feeders are rated at varying degrees of chamber filling, typically quoting figures for sixty, seventy or eighty percent. The other area of rating information usually relates to the back pressure against which they can be made to operate. Rotary Vane feeders, therefore are rather rudimentary as feeding devices in that if their chambers are not totally filled, they become difficult to turn and are subject to more rapid wear. In use, the chambers are invariably not totally filled.

As these feeders have been applied to construction plant applications, they have usually been fixed to the base of a cement silo with an often not very steep conical outlet. Cement in particular, as well as flyash and lime, usually show a great lack of willingness to flow through small diameter conical outlets, particularly if the material has been stored overnight. It is therefore almost universal practice in earlier systems to aerate these conical outlets so as to ease the bridging, and to bring the material to fluidised form.

See-through model studies of these devices have established that at the point at which material can be made to flow, a very unstable regime exists and that aeration produces waves of voids through the then fluidised material. It can also be seen that since a fluidised cement behaves more like a liquid than a solid and that the ultimate flow of material through the throat of the silo is also dependant on the head of material in the silo.

Since these feed devices are relatively small in displacement per unit revolution compared with the rate of feed which is required, it is normal for them to be run at speeds which do not allow the chamber to be uniformly filled. The flow of material from the silo ultimately becomes a significant determinant factor in how much material enters the chamber as the speed is increased. It is therefore, normal for the calibration curves of these feeders to be non-linear and to droop off as feeders speed increases because the flow into the feeder is sensitive to aeration and head height. The calibration reduces to a family of curves.

To use a rotary vane feeder as an accurate measuring system introduces great difficulty when an attempt is made to determine which point on the family of curves is the operating calibration at any given time. Various elaborate and complicated systems have been developed and are observable in field machinery to try to alleviate this problem. Some have metered materials separately into a further smaller capacity surge hopper with level probes to control the range of head at which it is required to operate. It is still usual to observe that even these small surge feed hoppers have aeration ports at the entry to the metering feeder.

Other systems even include load cell supported surge feed hoppers whereby the feed down rate is controlled by a computerized automatic control system which attempts to modify feeder speed to compensate for difference in feed characteristics from this aerated hopper. An ability to meaningfully and accurately weigh aerated material in a hopper whilst air voids are surging through the material is somewhat questionable.

It is observed that generally speaking, operators have difficulty meeting even quite broad cement content tolerances with such systems. Following experience with a variety of feeders, including the rotary vane type, and a thorough investigation into their behaviour and characteristics, ARAN Equipment Pty Ltd developed the ARAN ABFC Series sealed internally cleated belt feeders which are the subject of wide ranging patents and patent applications. The system is now universally used on all ARAN plants. (Older plants using earlier systems having been rapidly converted by their owners when the greatly improved results achieved by this system were observed).

In the ARAN cement metering system, the silo is designed with a large steeply sloped throat opening. This opening is typically of the order of two feet by three feet. It can be easily recognised that no bridging occurs with such a throat and that the cement can freely flow through it without need for any aeration whatsoever. The elimination of aeration removes a most serious and significant cause of error in other systems. Secondly, the chamber dimension is such that having a depth of only approximately one and a half inches (40 mm), the material has no difficulty in filling the cross section of the feeder uniformly, smoothly and completely.

The ARAN ABFC Series feeders are designed to handle the head of material present in the silo when appropriate ARAN specified venting systems resist filling pressures. Handling of the cement in the silo is also a critical factor and ARAN Equipment Pty Ltd designed filling and venting systems accomplish a uniform settlement within the silo itself. It has been argued that the density of cement varies within a storage vessel depending on the head. Whilst this is true in some measure the movement of the material as it is sheared from the bottom of the gradually lowering body of cement has some density reclassification effect, which tends to negate that characteristic. Extensive tests including feeder calibration measurements during the filling of the silo, with differing heads of cements and following settlement produced no measurable difference which was able to be correlated with those conditions.

Properly calibrated and properly maintained ARAN silo and feeder system combination, operated in accordance with instructions, can be controlled within plus or minus one percent of its calibrated characteristic. That is to say, if the specified cement content is say, 200 pounds per cubic yard or 200 kilograms per cubic metre then a result of between 199 and 200 is achievable. In some applications, this degree of accuracy is not necessary and wider tolerance bands are often permitted and used by mixing plant operators. A tolerance band of plus or minus two percent can be achieved by most operators of ARAN Equipment plant, exercising normal care. If for instance, the cement content is say 10 percent of the total mix, then this means that the cement content should be able to be contained to within 9.8 to 10.2 percent or better.

This performance is more than comparable to batching plant cement addition accuracy and the degree of its control is a function of plant maintenance operator care and whether or not the system is automatic or manual as is the case also in a batching situation. Likewise flyash and lime can be measured with similar degrees of accuracy. Because of the way in which this very successful, accurate, uniform, consistent and linear, ARAN ABFC feeding system is designed, it is neither practical nor meaningful to incorporate a weighing element within it. Pressures and forces exist within the dispensing flume due to the sealing elements which, if weighed, would register loads other than the actual cement itself. Since cement is a fluidisable fine material which is easily windborn in handling, it is considered better not to put it onto an open belt feeder or similar for confirmatory weighing because in effect in this accurate ARAN system such a procedure serves no purpose.

<u>Calibration and Quality Monitoring Procedures for Aran Cement Feeders</u>

In many mixing projects on cement treated based and similar, less careful operators tend to use the quality controlled procedures of the specifing authority as the basis of their measuring feeder setting. That is to say, that they adjust it up or down in response to tests such as a titration test or a heat of neutralisation test, (which is commonly used in Australia).

As a supplier we actively encourage and train users and operators to calibrate their feeders properly in respect to each different source of cement or flyash being used. On manually operated plants each feeder is equipped with a sensitive digital pulse generated speed tachometer which reads to three digits, that is, to one part in 999.

The correct procedure requires that a sample of cement or flyash be taken whilst the feeder is run against an accurately operated stopwatch at a set tachometer digital reading. The mass of cement so dispensed is weighed and a mass flow-rate at a particular setting is established. A series of such calibration tests are carried out at varying feeder operating speeds selected at random. The resulting feed rate versus speed calibration curve is inevitably totally linear and is accurately repeatable from one day to the next provided that the cement is of the same type. Plant set up then simply involves the correlation of the three digit tachometer setting with the required additive rate. (The base rate of the aggregate feed in manual plants is fixed as the non-variable parameter).

On systems fitted with pulse-totalisers (most plants operating in the USA have these totalisers), it is possible to correlate the total mass collected during calibration sampling with the total number of tachometer pulses recorded. This gives a macro check of the calibration factor. In practice it has been found that plants calibrated and operated in this manner, where pulses are recorded and feeders are properly maintained, correlate with an extreme degree of accuracy with cement purchased from the cement works and measured over the weighbridge.

Reports from operations by P.J. Beaumont and by Pioneer Concrete are included as an appendix. For example, during the production of roller compacted concrete from the Kidston Goldmine dam in Northern Australia, cement delivered from the cement works during the key part of the project, correlated to within two tons of plant calibration over a quantity of 2450 tons.

New ARAN ASR280C automatic continuous mixing plants adopt an even more sensitive and accurate procedure. Each feeder, be it for sand, aggregate, cement, flyash, water, admixture, or whatever, is fitted with a digital pulse counter. In the case of a cement feeder for example, each revolution is divided into 720 discrete units. This translates to approximately 30 grams or one ounce of cement per pulse which forms the basis of control through a loop feedback, automatic control system. When the plant is calibrated, a sample of cement is collected in a similar manner to a manual machine. The control system registers the number of pulses of feed which have been dispensed. The resultant weight is entered and the feed factor is computed to hundredths of grams per pulse. Calibration is normally repeated several times to ensure consistency of the calibration factor.

Once set up, this system maintains the cement addition rate in accordance with the pre-set memory stored ingredient proportions in correct relationship to the master aggregate feed which is likewise pulse-monitored and controlled after redensification with these systems. A degree of repeatability well superior to batching plant uniformity is able to be achieved without the introduction of continous weighing systems on the spurious factors which in fact they introduce.

Measuring of Water

The handling of water in any mixing process is in many ways the most difficult because of resident moisture in incoming feed materials. In reality water has to be adjusted to match the end moisture content requirement of the product, be it compactability in the case of roller compacted concrete or cement treated base, or slump in the case of conventional concrete.

Water is metered in ARAN systems by using positive displacement pumping devices which are calibrated in like manner to the positive displacement cement feeder and registered using a sensitive digital pulse tachometer. Automatically controlled ARAN ASR280C plants drive these feeds in response to ingredient recipes but include a trimming facility to allow adjustment for incoming moisture and/or temperature and weather conditions during the day. Admixture measuring systems, if fitted are handled in like manner.

Mixing

Irrespective of how accurately, repeatably, and sensitively ingredients are metered this is of little benefit if they are not mixed together in a manner appropriate to the material being processed. ARAN ASR series continuous mixing plants have been applied successfully and effectively over a wide range of material types, from the moisturisation or treatment of fine plastic soils used as fill materials, through accurately graded and controlled fine crushed rock for tightly specified airport constructions, cement treated base, roller compacted concrete, and now to tightly specified paving quality concrete. The ARAN mixer has been developed and expanded to handle all of these material types.

The basic mixer fitted to ARAN ASR200 and ASR280B type machines is a high energy suspension type mixer in which the major mixing is carried out in suspension by collision and interaction of materials with each other. The new ASR280C series machine has the facility to adjust the mixing conditions through speed adjustment, mixer blade pitch angle, and inclination adjustment. This allows it to handle concrete having in excess of a four inch slump, through to totally dry materials with very effective cement, moisture and particle dispersement.

Tests carried out in conjunction with a major slip form paving project in New South Wales, Australia have indicated that the new ARAN ASR280C series machine working in conjunction with an ARAN AFSM4 multi-compartment blending plant, and an ARAN ACSM50 ancillary flyash system have enabled mix designs to be developed without the need for provision of excessive cement to compensate for mixing variations. By careful attention to mix design, this plant has been able to achieve specified strength and density requirements with significantly less cement and flyash than has been found necessary in other slip formed paving work in that State in the past several years when using modern automatic batching plants. A major reason for this has been the machines consistency of the metering accuracy, and the uniformity of mixing when compared with batching alternatives.

The accuracy and uniformity of properly maintained ARAN plant systems is attested by literally hundreds of successful within-specification projects carried out every year. The appendix section of this discussion includes field copies of calibration reports on manual feeders, as well as sight reports and analyses of test results from manually controlled plants. It also includes preliminary testing reports on the ARAN ASR280C system indicating the extreme uniformity of the mix irrespective of whether it was taken from the beginning, middle or end of a run.

ARAN plants, because of their patented layout and configuration, have the unique ability to produce on specification materials without difficulty from initiation of a feed run to its finish. This means that small quantities can be individually prepared simply by simultaneously stopping and starting of all feeders. It is not necessary for ARAN plants to run continuously and to feed large stock piles or surge hoppers for accurate results to be obtained.

The results achieved by ARAN ASR series plants are not normally achieved or achievable by alternative systems. ARAN Equipment developed feed and mixing systems have been the result of extensive field experience and performance monitoring, combined with a dedication to the innovative and effective creation of continually superior equipment using functionally simple but accurate solutions. It can be seen from an analysis of the philosophical basis of the measuring systems adopted that continuous weighing of materials is not necessarily appropriate, beneficial, or logical if appropriate measures are taken to bring the material to the condition in which it will exist in the finished product at the point of measuring.

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